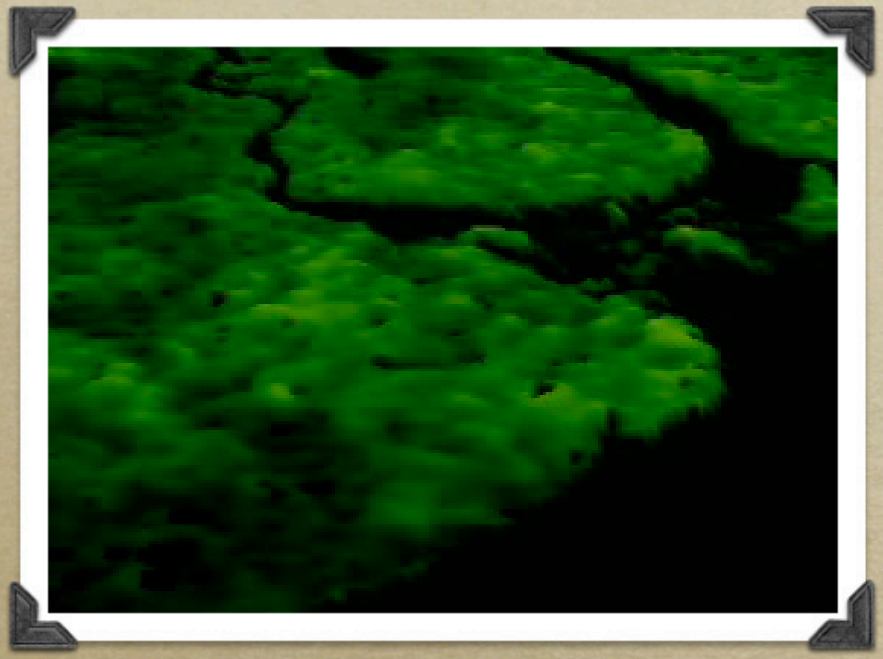
Using Shuttle Radar Topography Mission Elevation Data to Map Mangrove Forest Height in the Caribbean



Marc Simard

(email: marc.simard@jpl.nasa.gov)

Caltech - NASA - Jet Propulsion Laboratory

K. Zhang(FIU), V. H. Rivera-Monroy(LSU), M. Ross (FIU)

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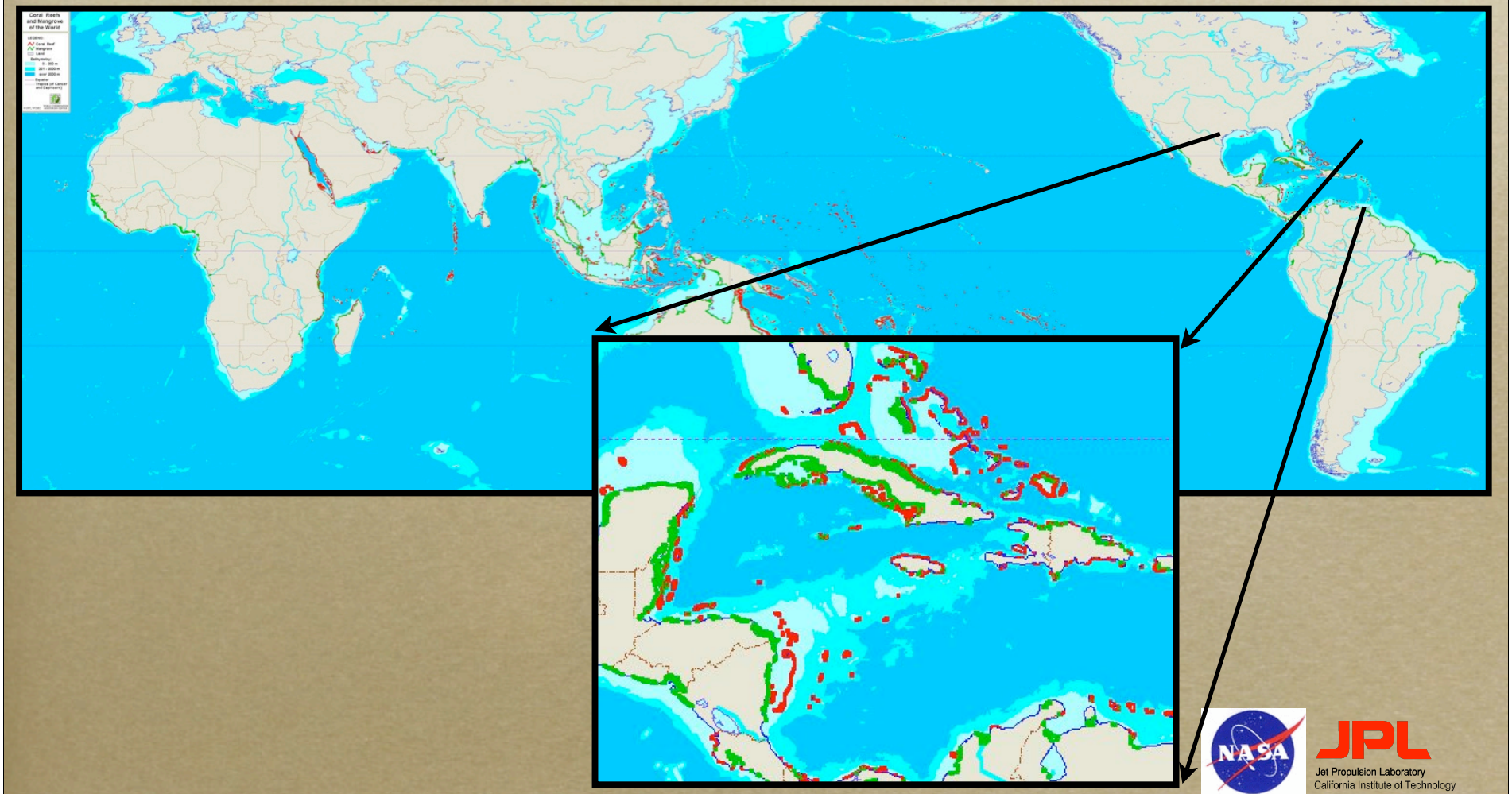
California Institute of Technology

Mangrove Distribution



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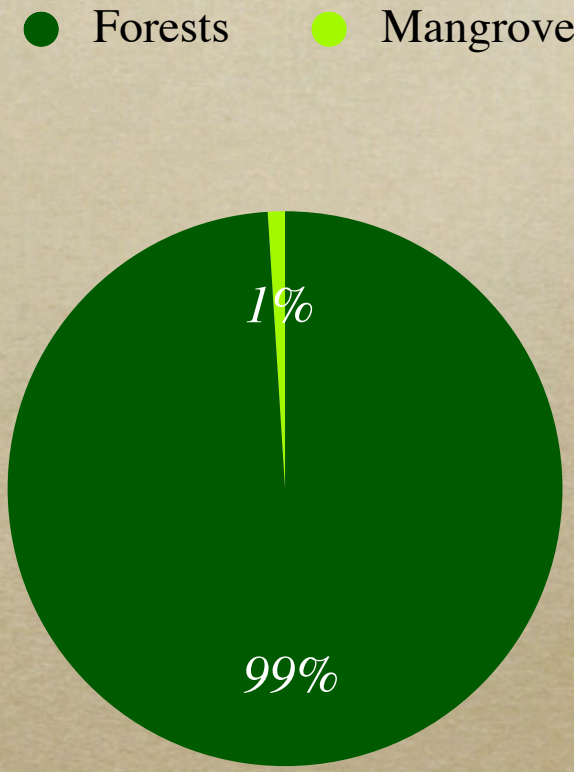
Why Mangroves?

- *Biodiversity*
  - *Habitats of 1300 species of animals*
    - *628 mammals, birds, reptiles, fish and amphibians*
- *Among the most productive ecosystems on earth*
  - *170k km² with mean 2.5g C m⁻² per day (10t/ha/yr)*



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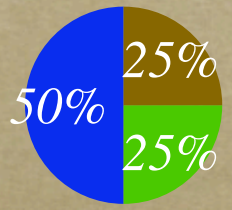
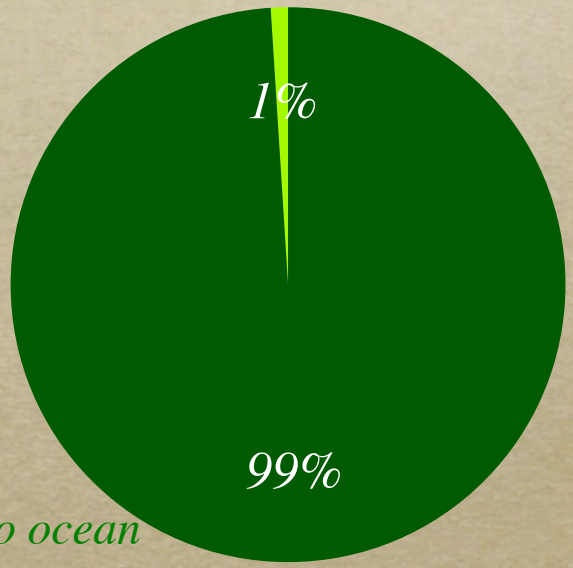


Mangrove Sediment
Recycled
Export ot Ocean

- *Annual input into ocean 46X10¹² g C*
  - *Thus contributes 11% of global total export to ocean*



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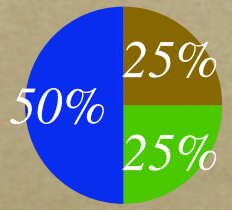

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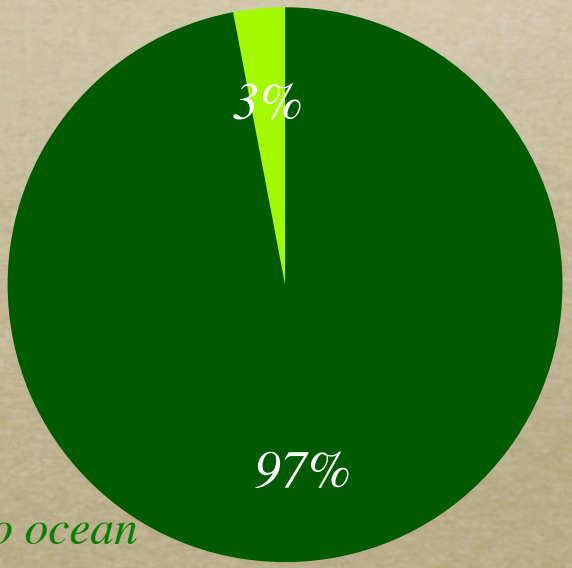

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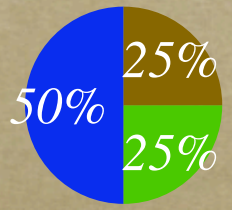

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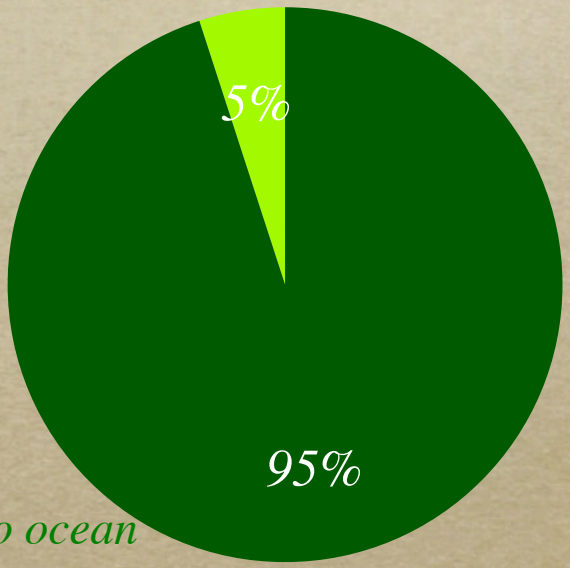

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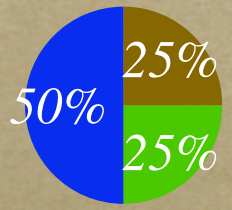

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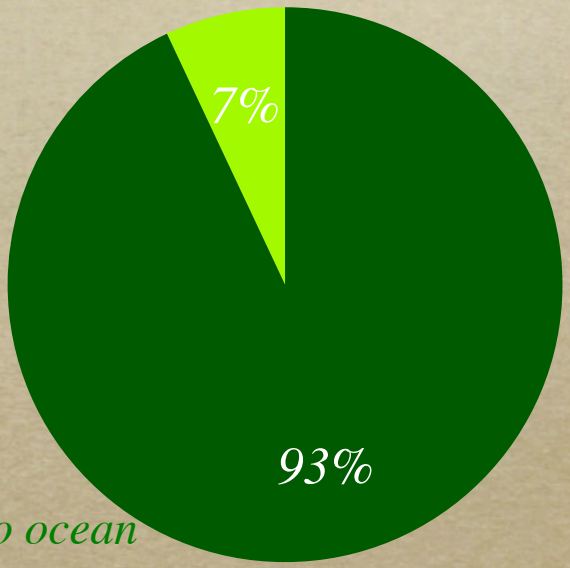

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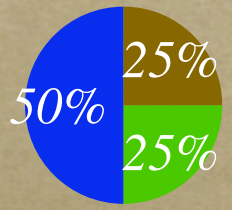

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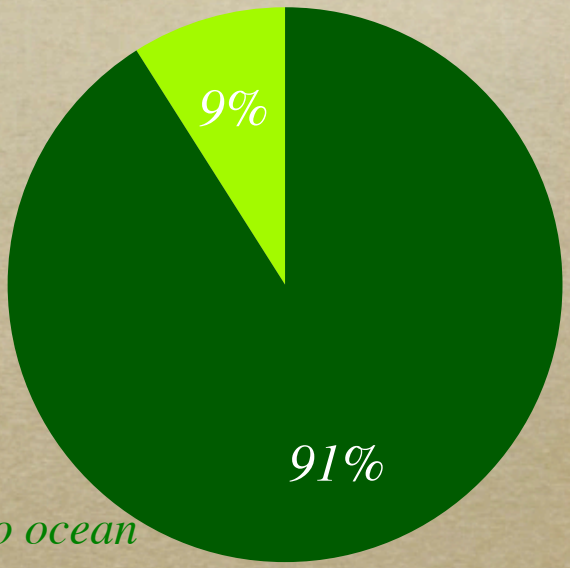

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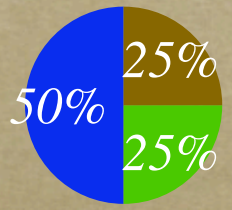

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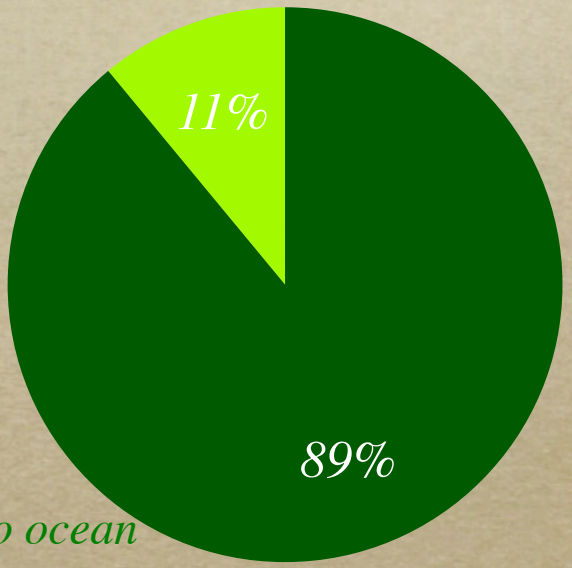

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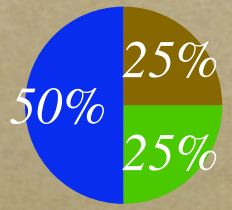

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  - *Annual input into ocean 46X10^{12} g C*
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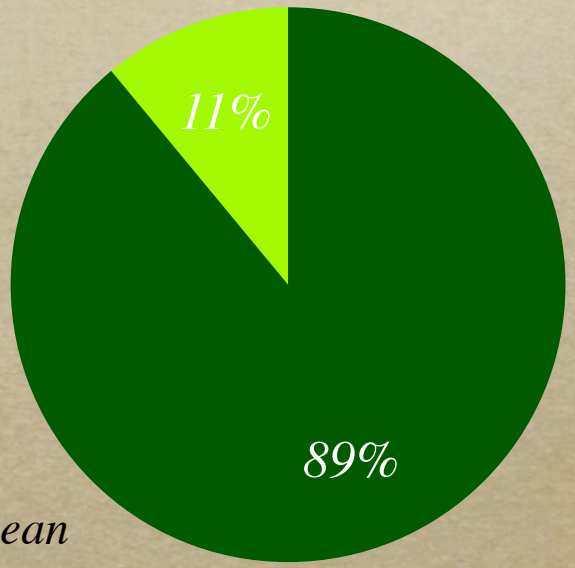
  - *Annual accumulation of carbon in modern sediments 23X10^{12}g C yr^{-1}*
    - *Contributing 15% of carbon accumulation in modern sediments.*



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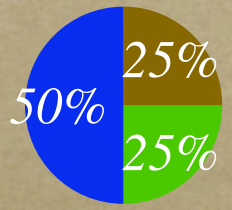

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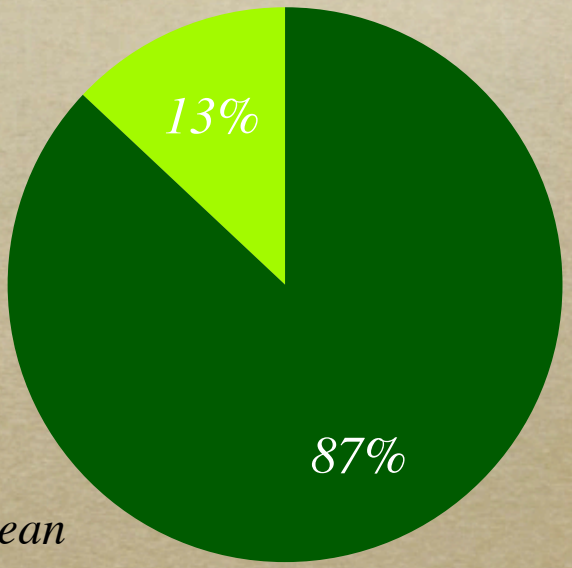

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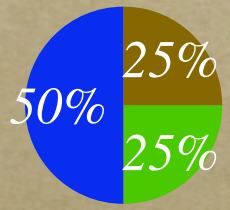

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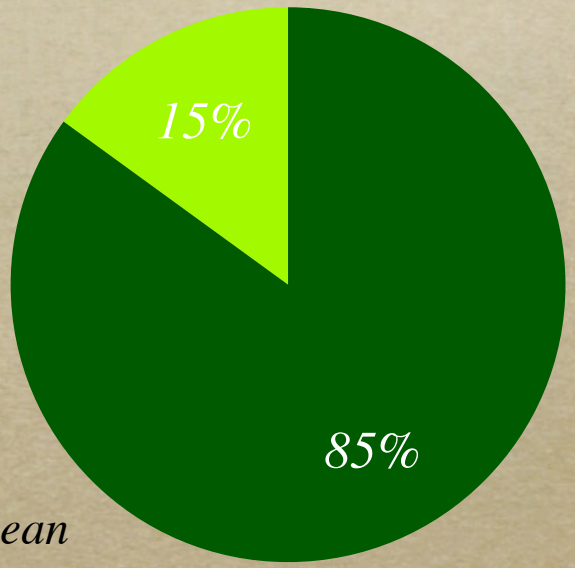
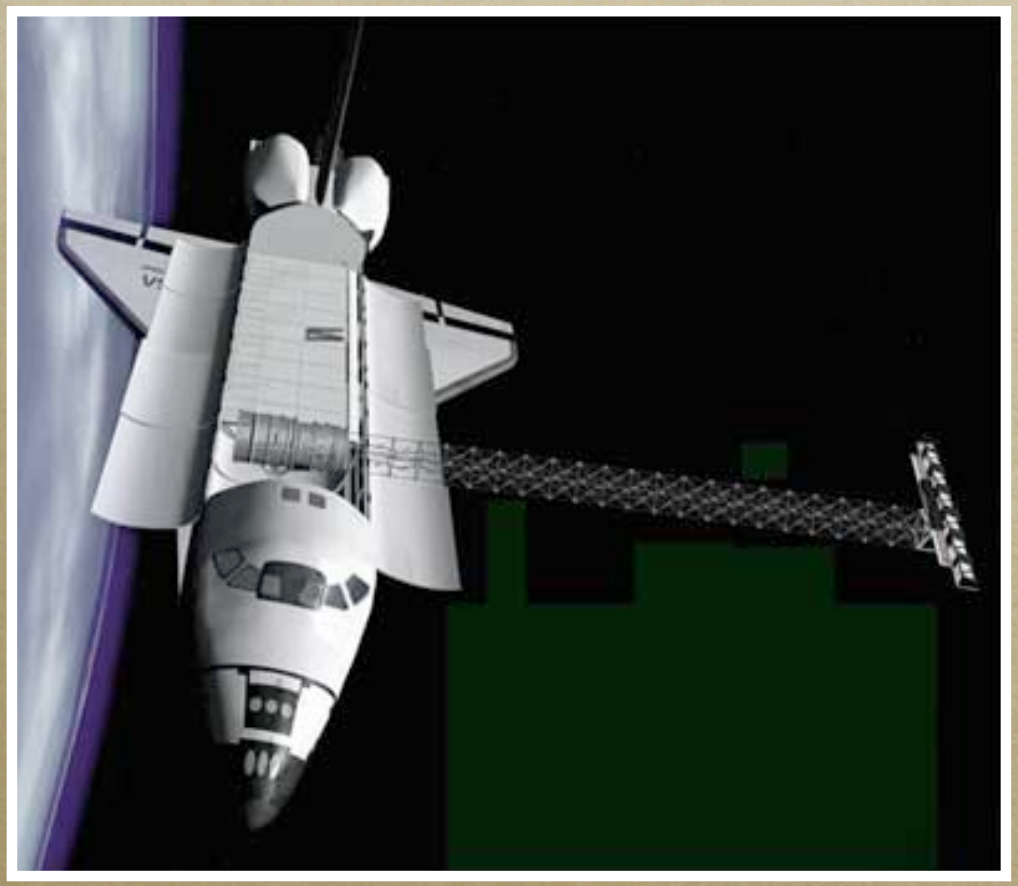


Mangroves Are Endangered

- *Endangered by Urbanization, exploitation and sea level rise*
- Already **35%** of mangrove forests have **disappeared** and **60%** could be lost by **2030 (UNEP report 2006);**
- The estimated **economical** value varies between $200k to **$900k** per km^2 per year (UNEP report 2006);

Shuttle Radar Topography Mission (SRTM)



1. *Radar Interferometer*
2. *60m boom*
3. *C and X band*
4. *11 days in February 2000.*
5. *80% Earth Land*
6. *Latitude 56S to 60N*
7. *30m US and World 90m*

http://www2.jpl.nasa.gov/srtm/

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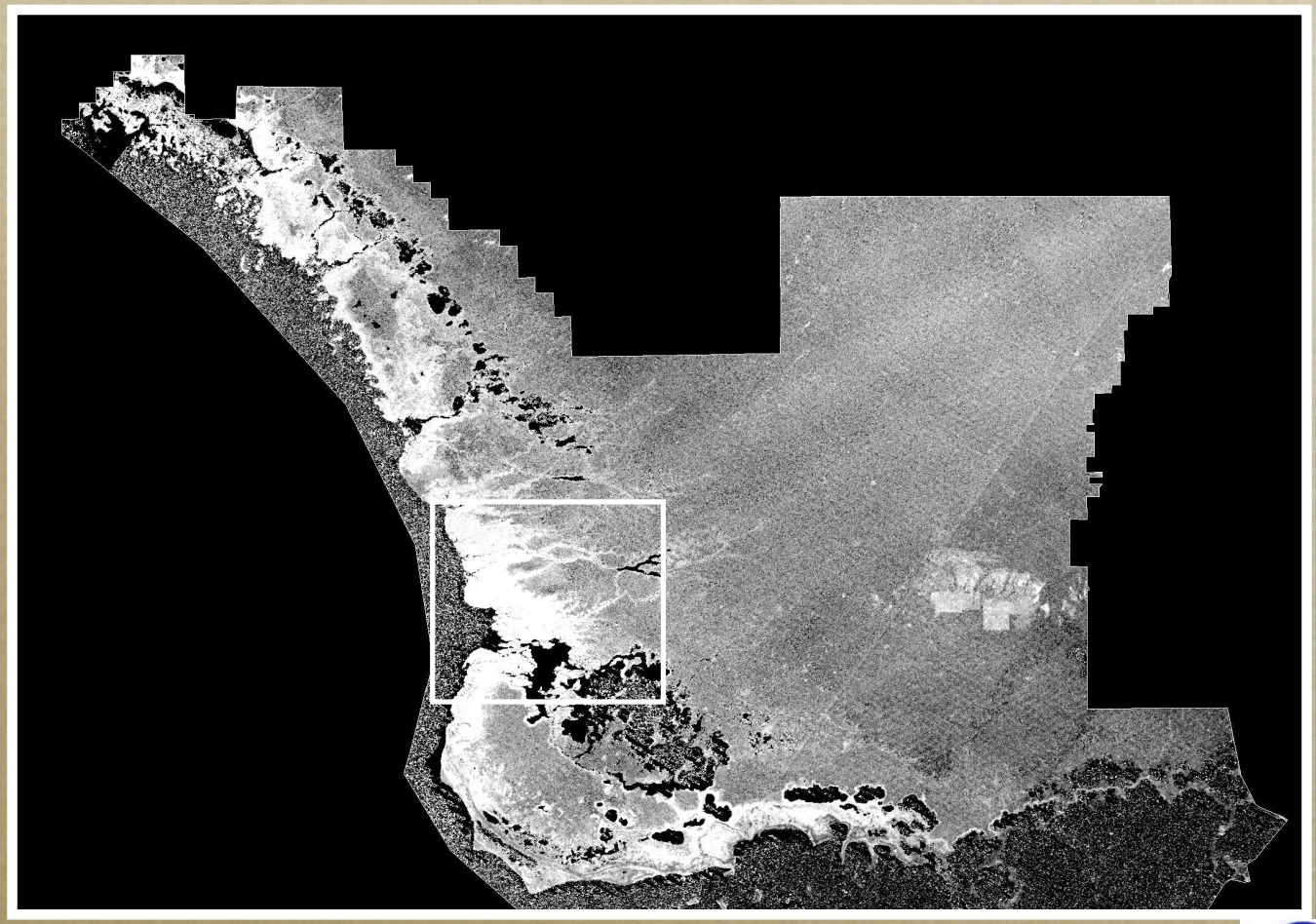
SRTM Elevation data



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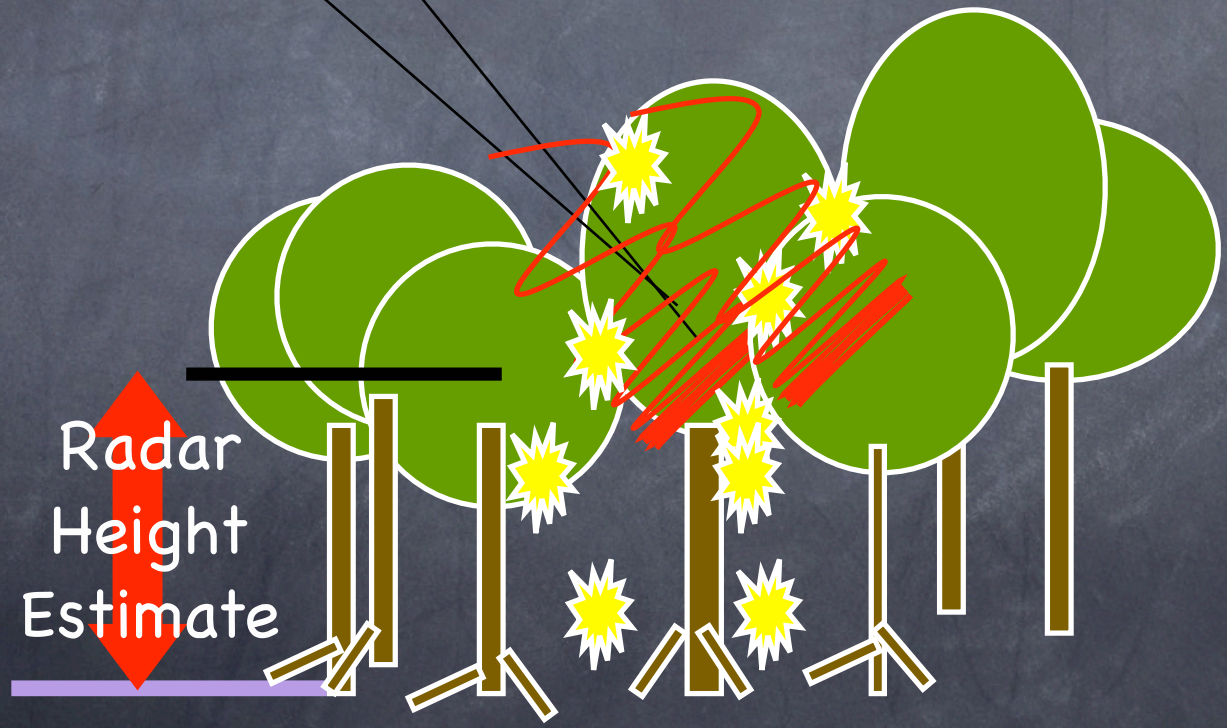
Relative Vegetation Height



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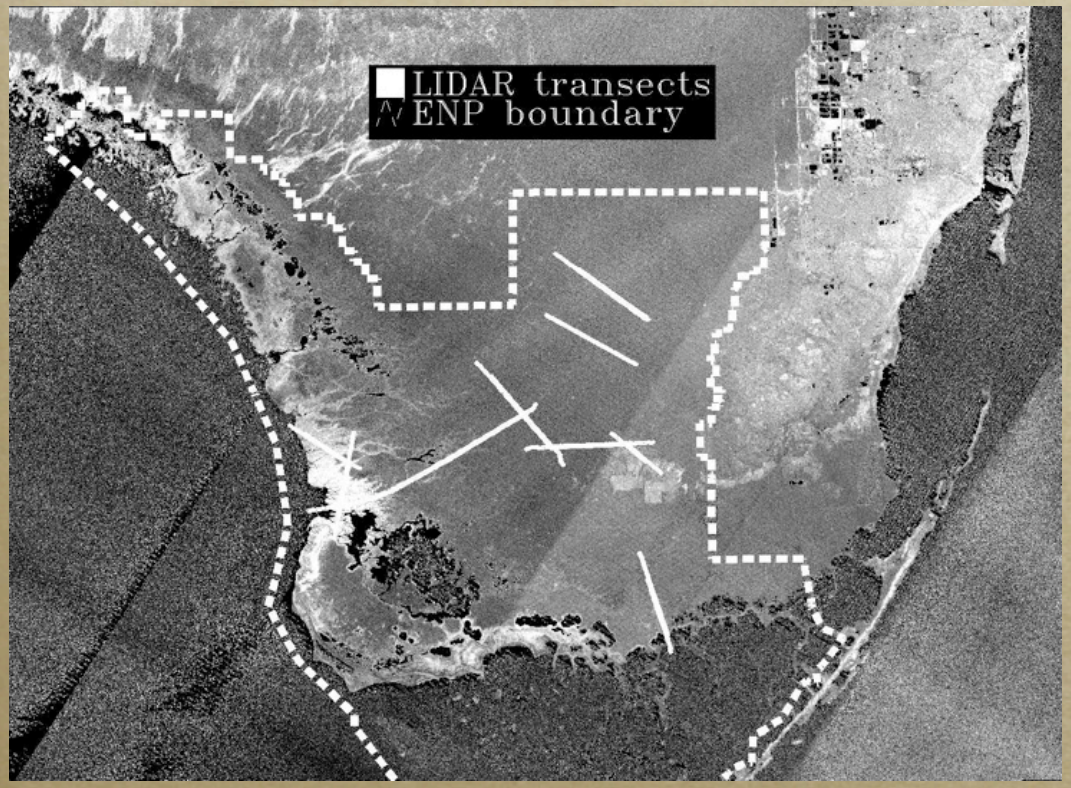
LIDAR Data



- *Optech 1233-infrared 1um*
- *First and last reflection method (No Waveform)*
- *Nominal Altitude of 500m*
  - *360m swath*
- *May 13-15 2004*
- *1.5m spacing with 13cm laser footprint*
- *15 cm elevation accuracy*

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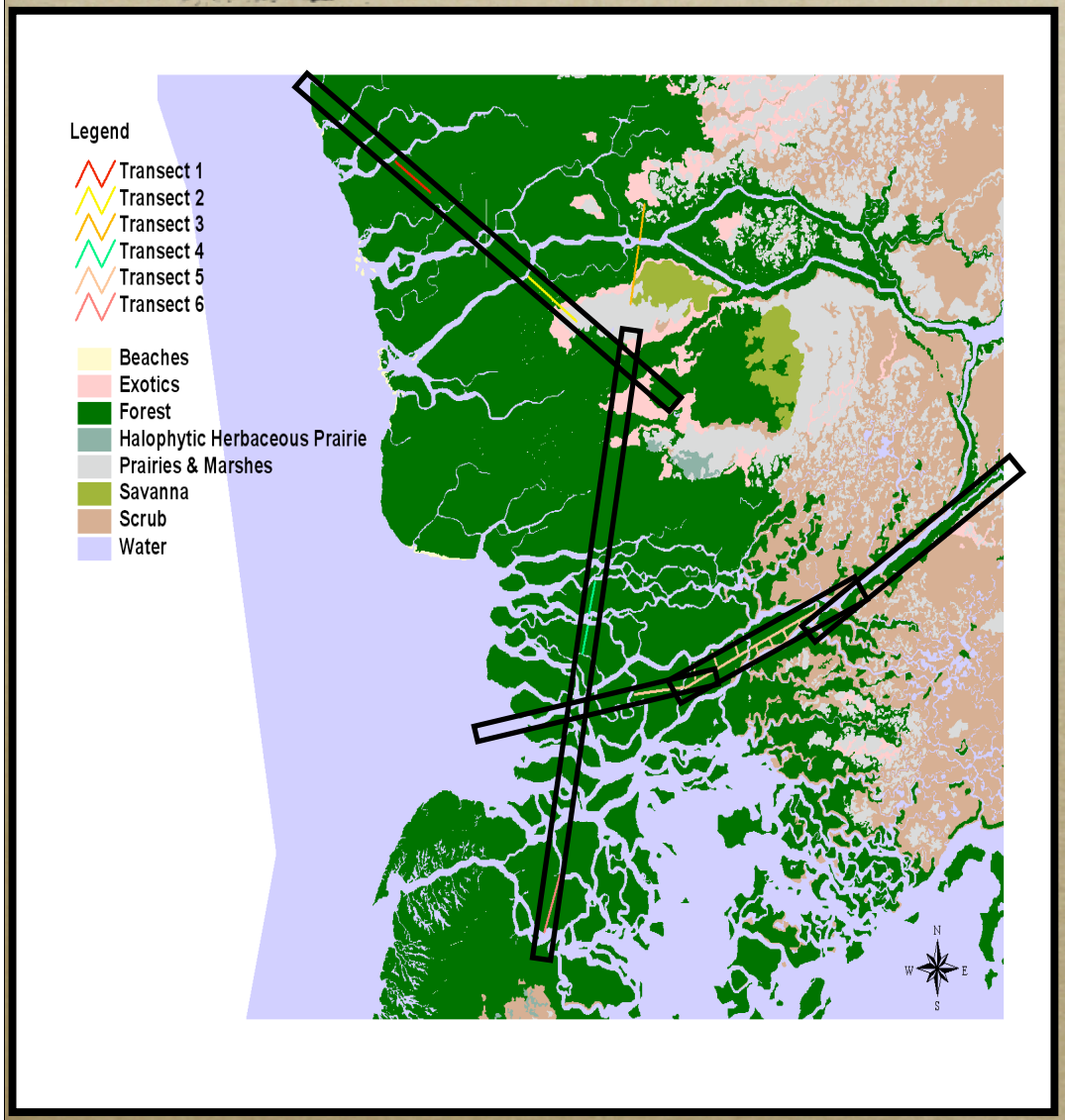
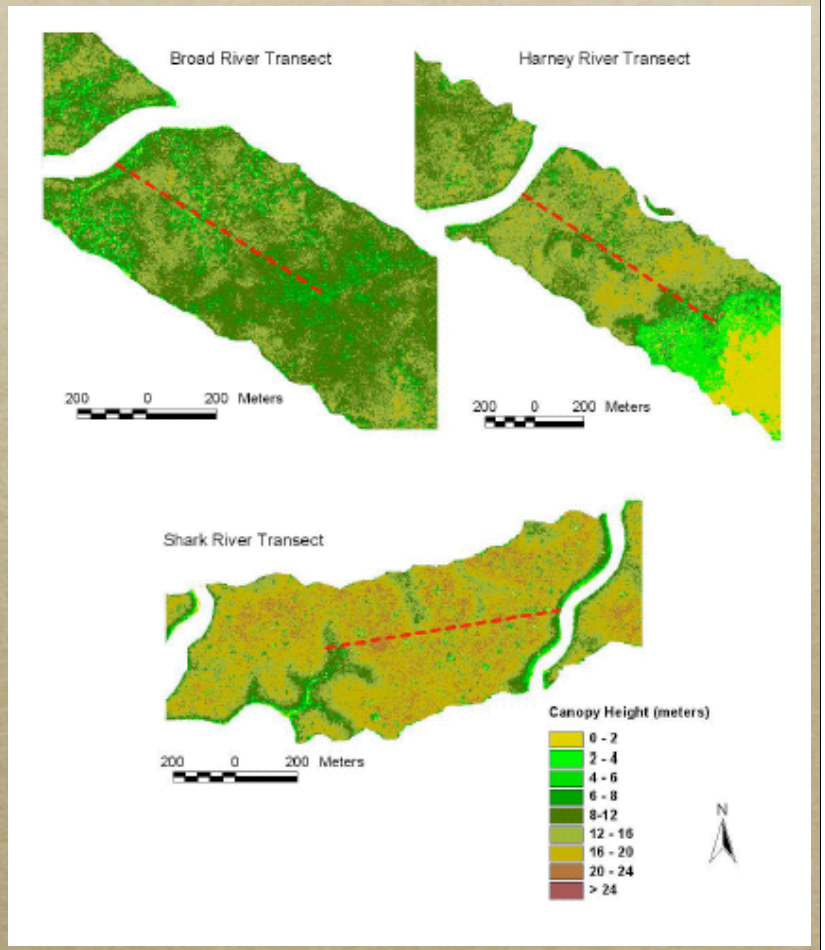
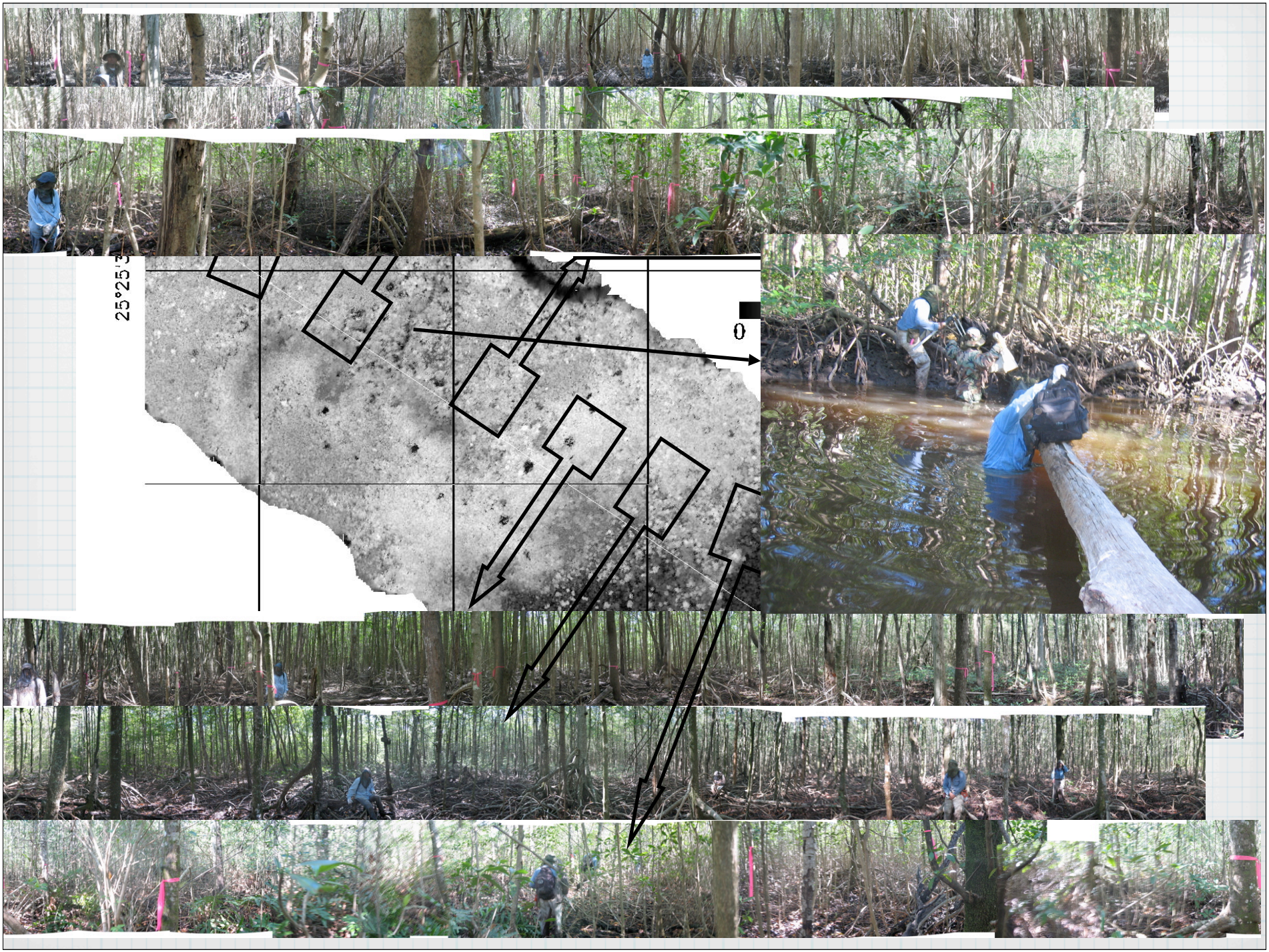
Lidar Tansects

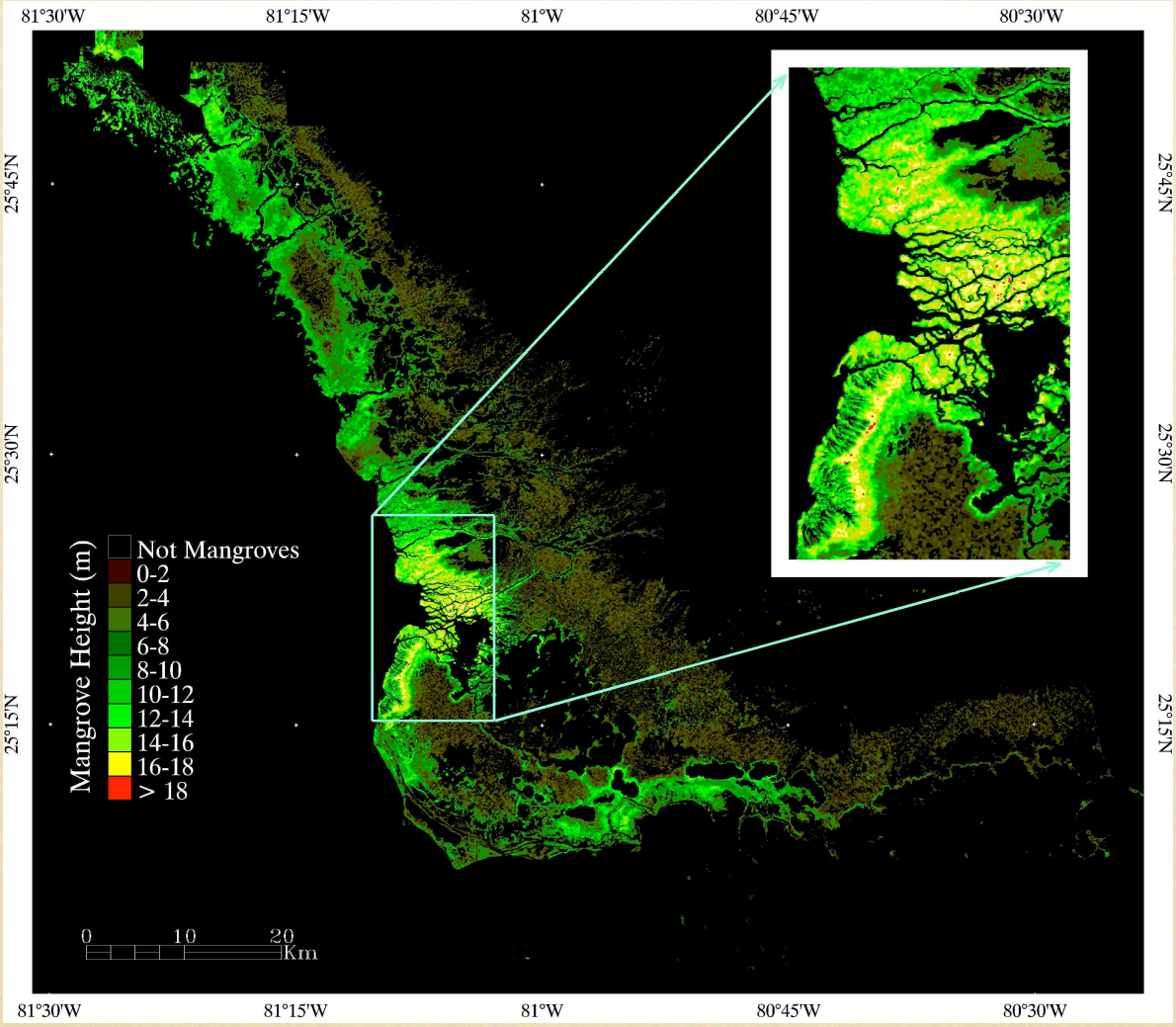





25°25'
0

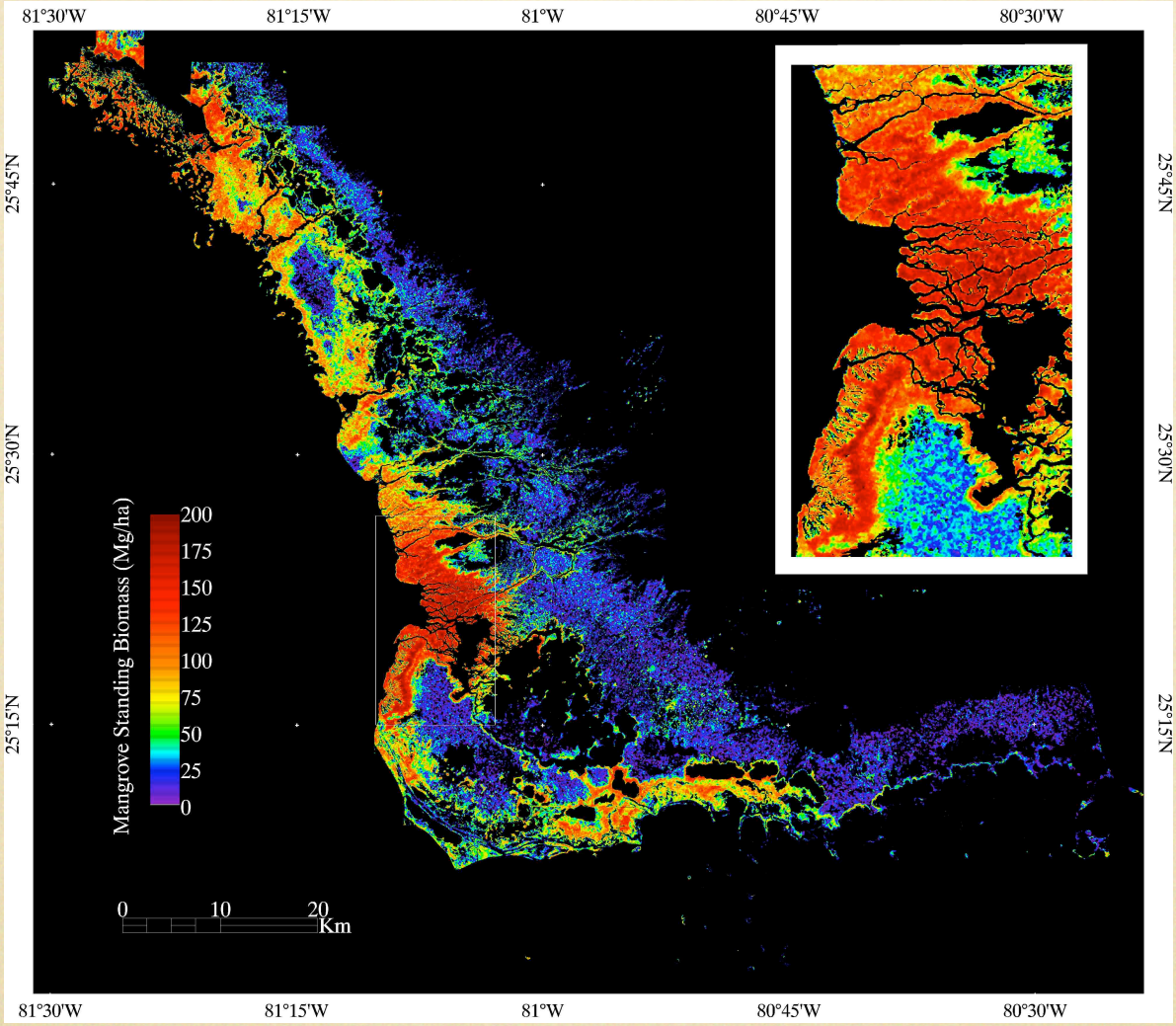
Results
Everglades National Park

Mapping Mangrove Forest Height in the Everglades National Park (ENP) Using SRTM



Marc Simard et al., "Mapping Height and Biomass of Mangrove Forests in Everglades National Park with SRTM Elevation Data", *Photogrammetric Engineering and Remote Sensing*, SRTM special issue, April 2006

Mapping Biomass of Mangrove Forest in the Everglades National Park (ENP) using SRTM



Global storage of Carbon in Mangrove Biomass* is (Twilley et al 1992): 4.03 x 10^{15} grams
Current first-rate estimation of carbon storage in Mangroves in the ENP is: 2.52 x 10^{12} grams (45%C DM)

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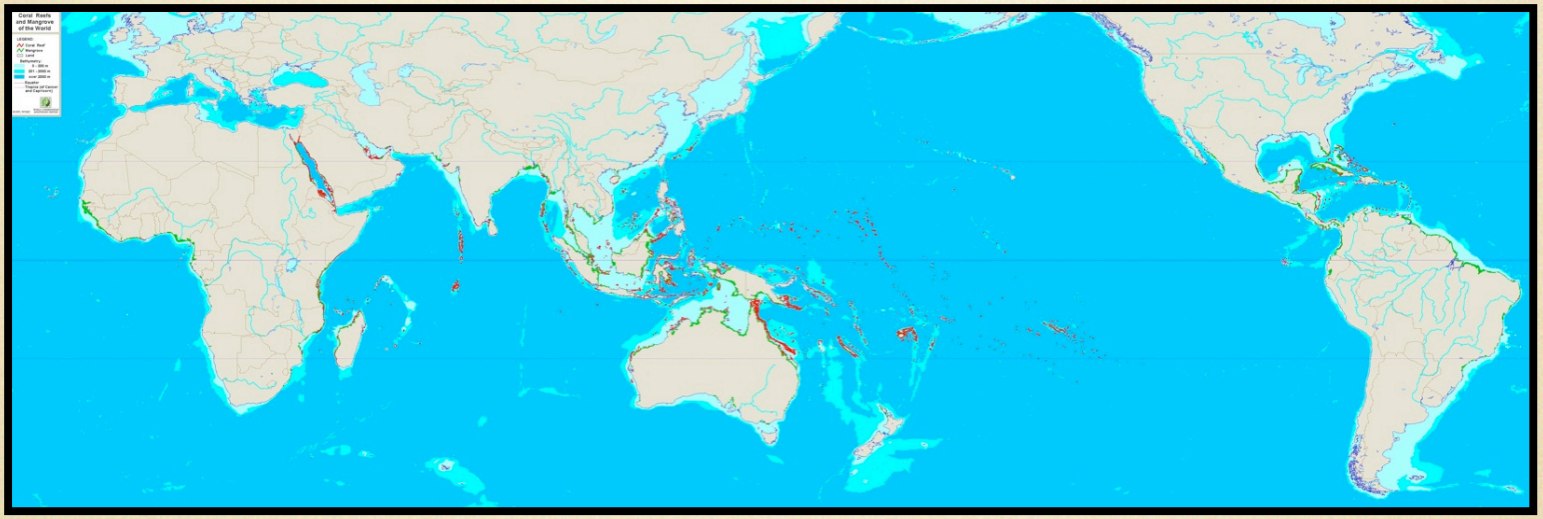
How to apply this methodology worldwide?

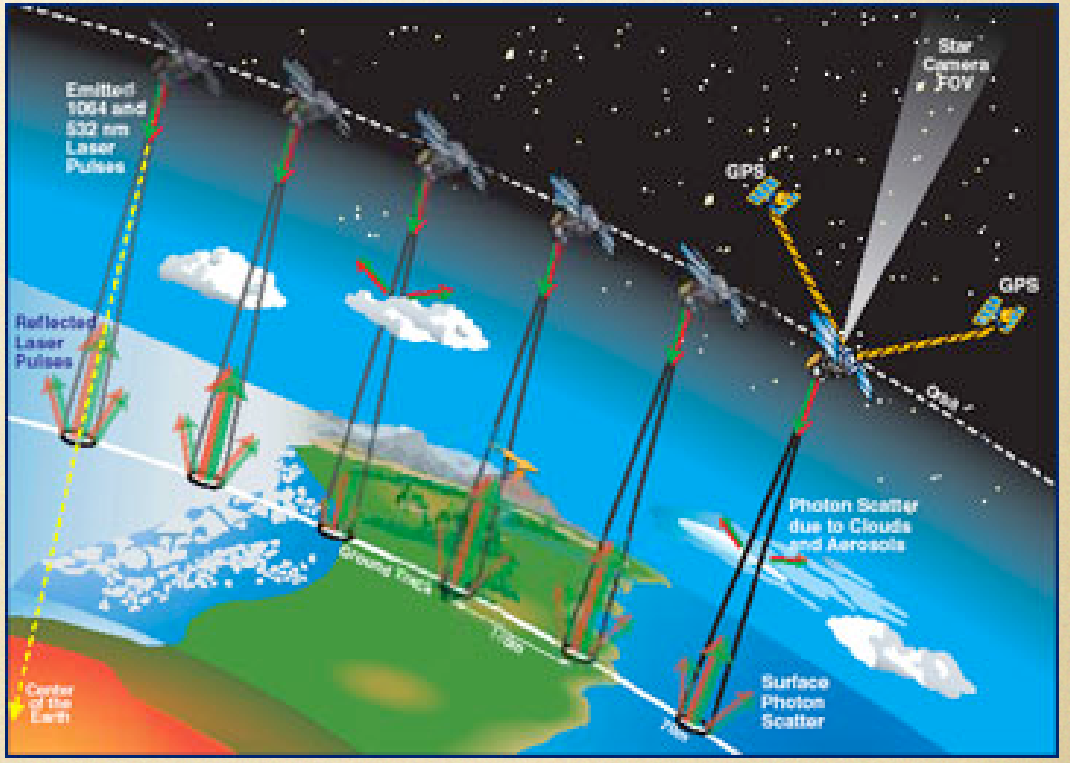


- Extrapolate results from other regions
- Use ICEsat data
- Collect field data

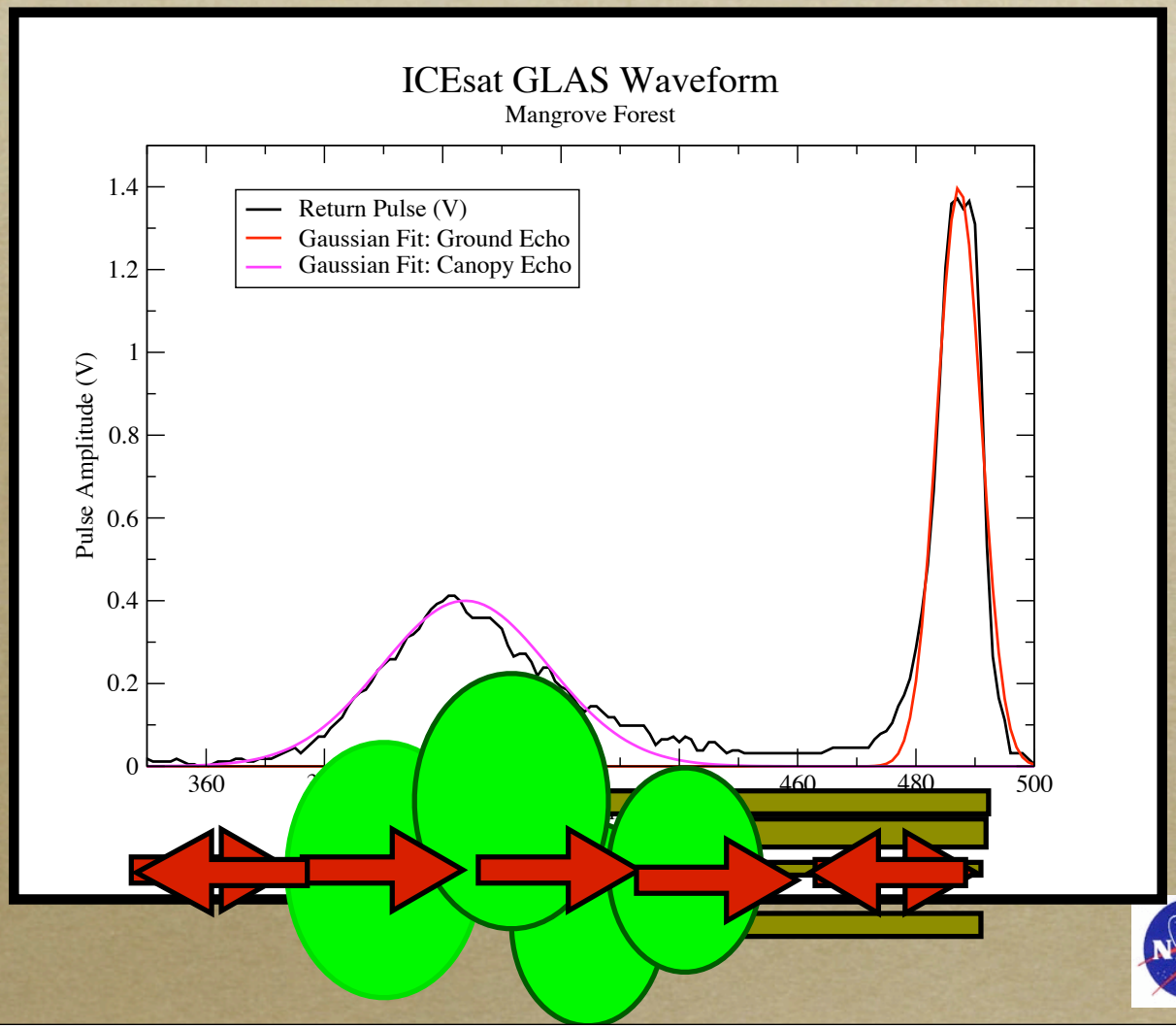
ICEsat/GLAS

Geoscience Laser Altimeter System

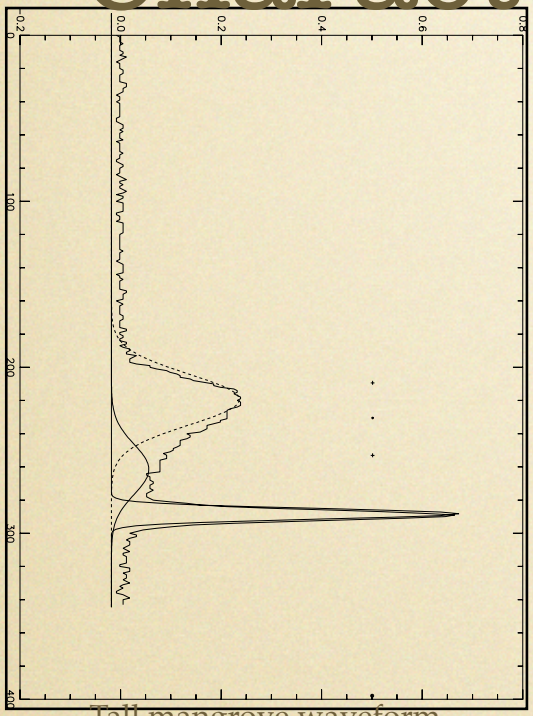
- 172m spacing
- 64m footprint



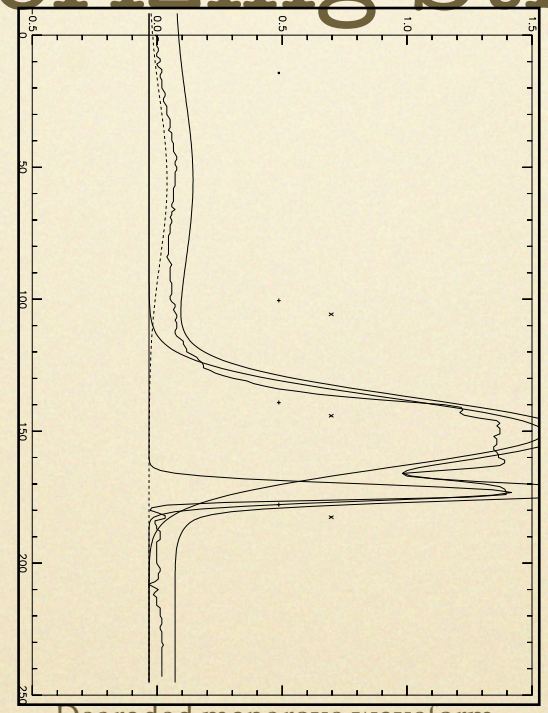
ICEsat/GLAS Waveform



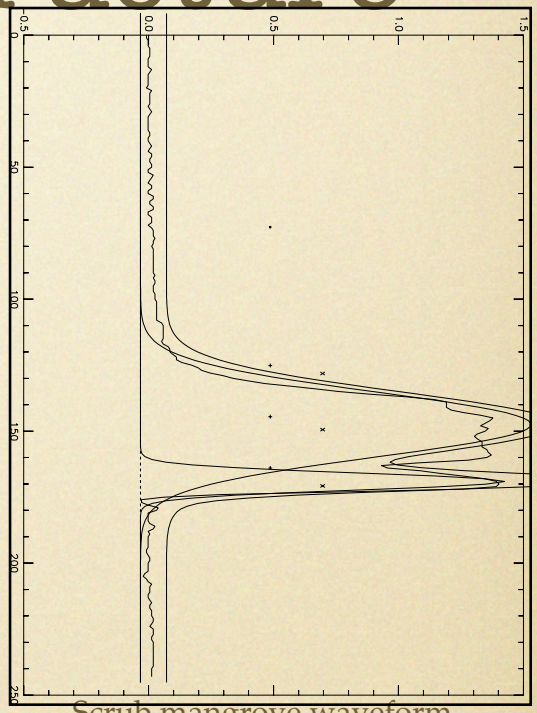
ICEsat Waveform: Characterizing Structure



Tall mangrove waveform



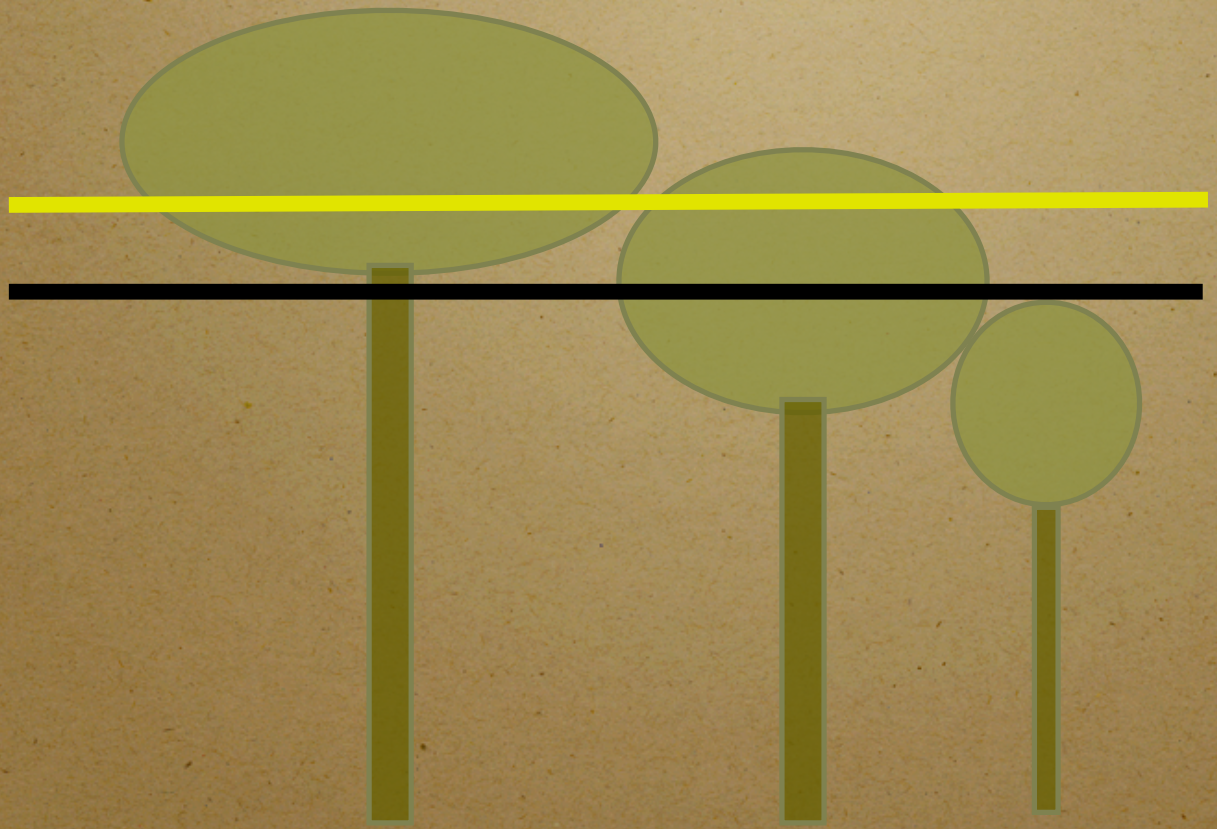
Degraded mangrove waveform



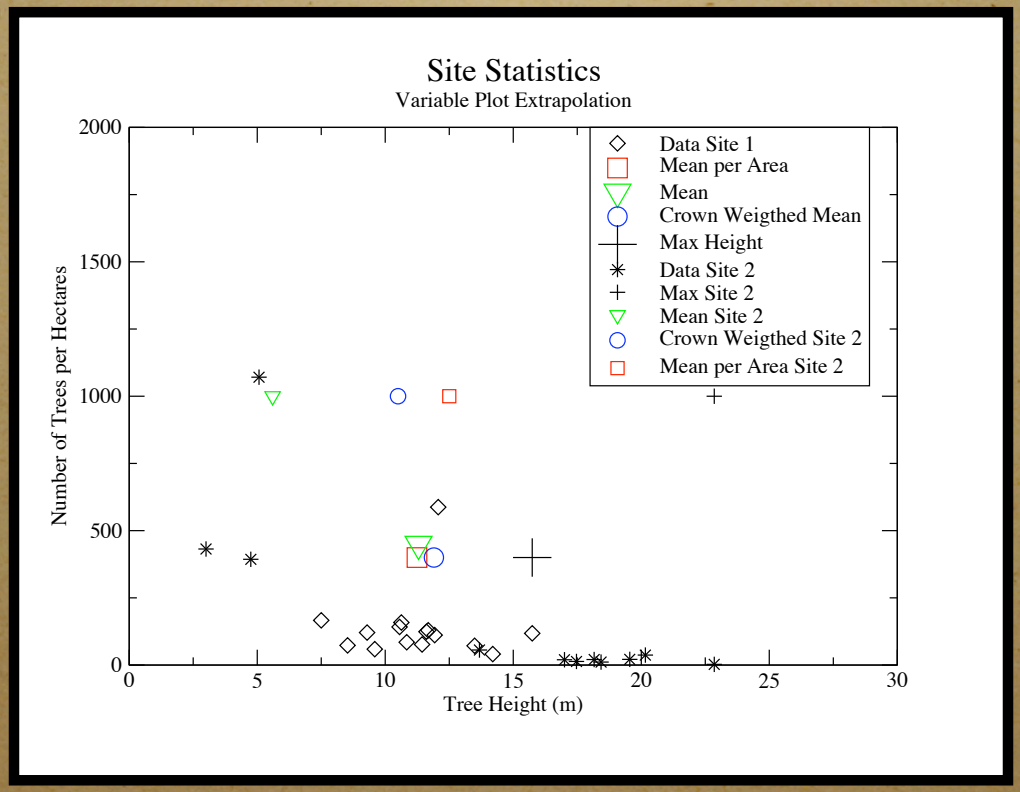
Scrub mangrove waveform

- Multiple Gaussians to fit ground, high and low canopies
- Compute waveform centroid
- Compute canopy waveform centroid

Mean Tree Height

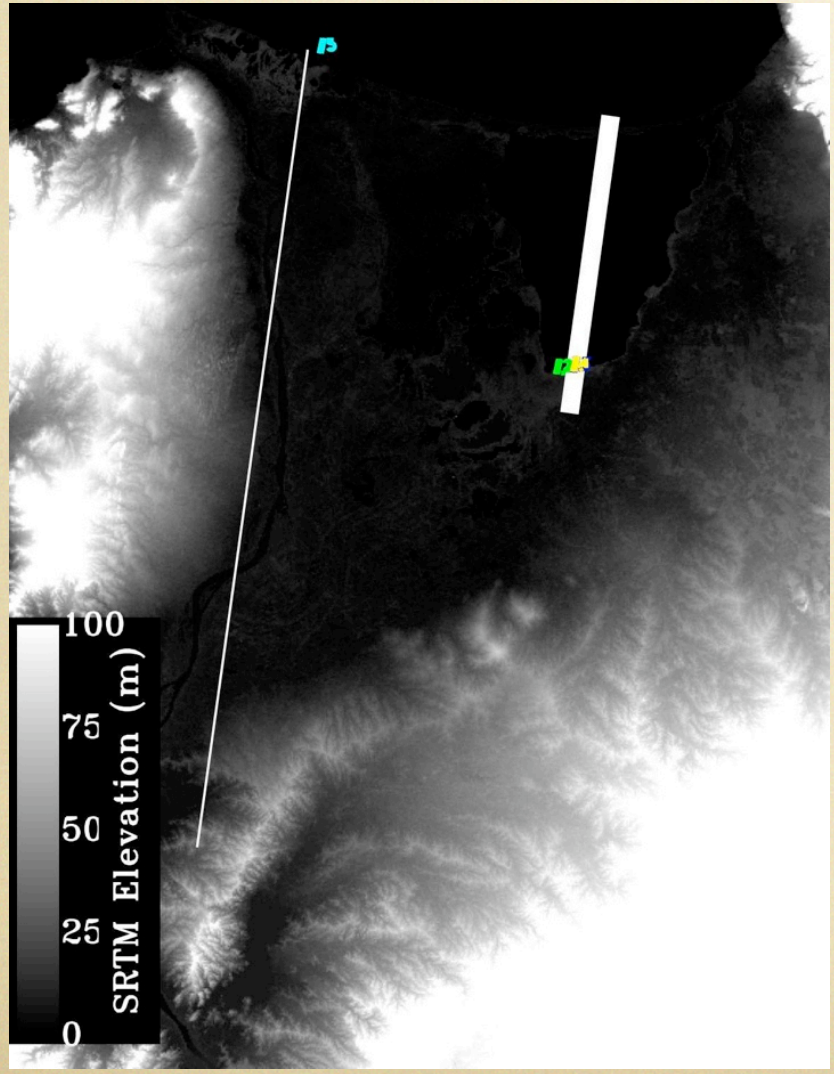


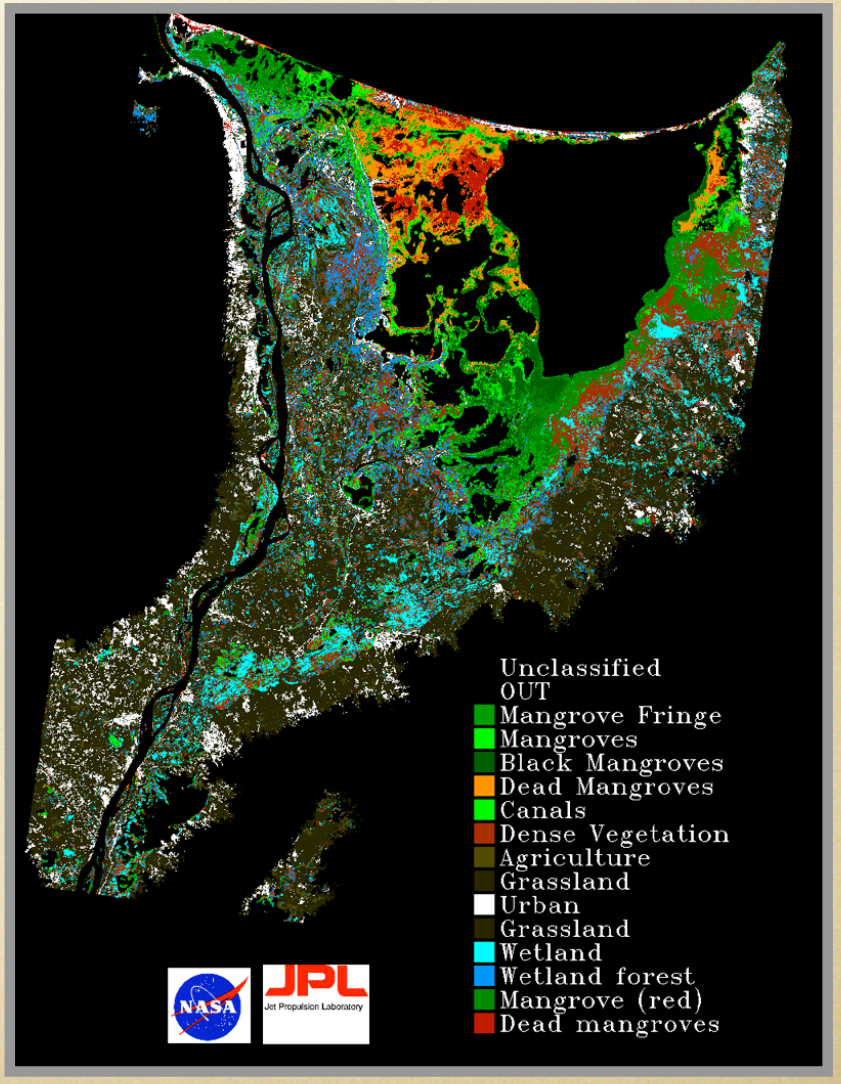
Field Data



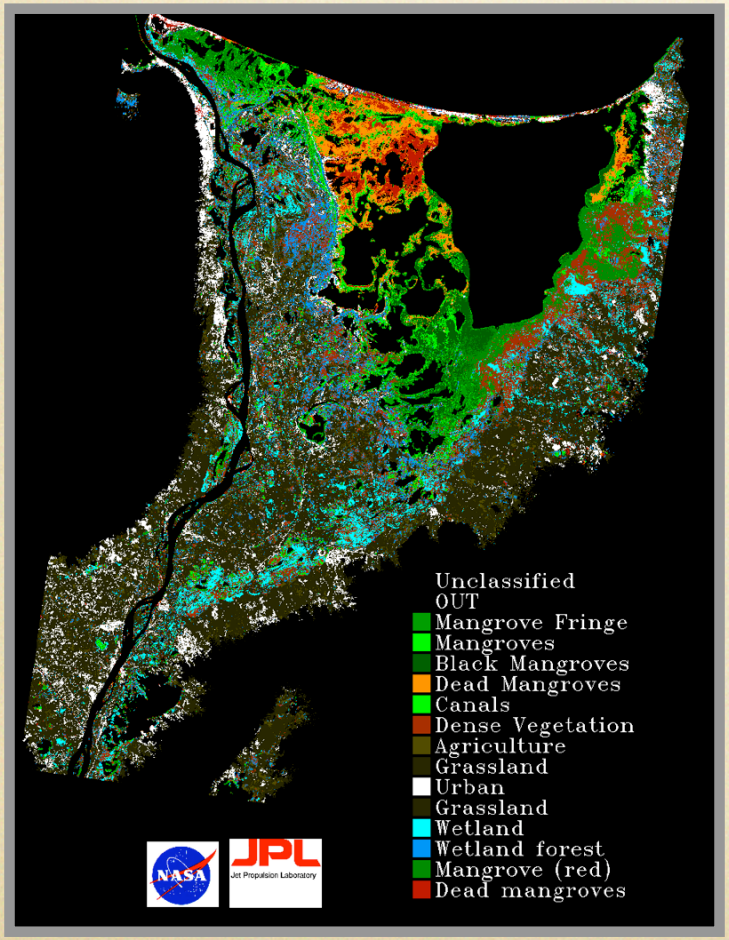
Forest height estimation

Cienaga Grande de Santa Marta, Colombia Calibrated with ICEsat LIDAR Waveforms

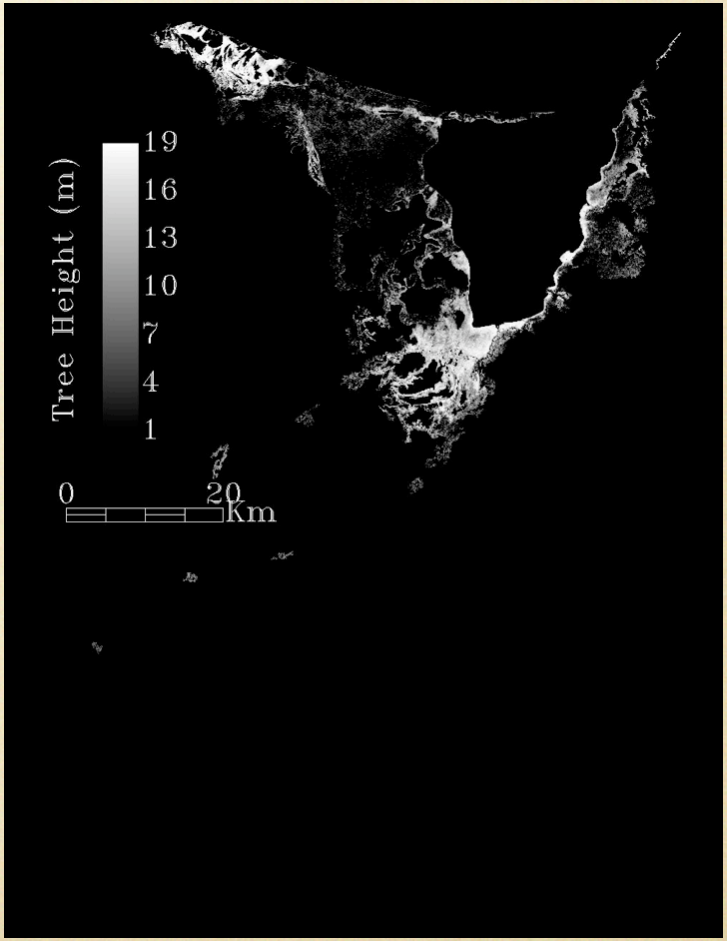




Cienaga Grande de Santa Marta, Colombia Calibrated with ICEsat LIDAR Waveforms



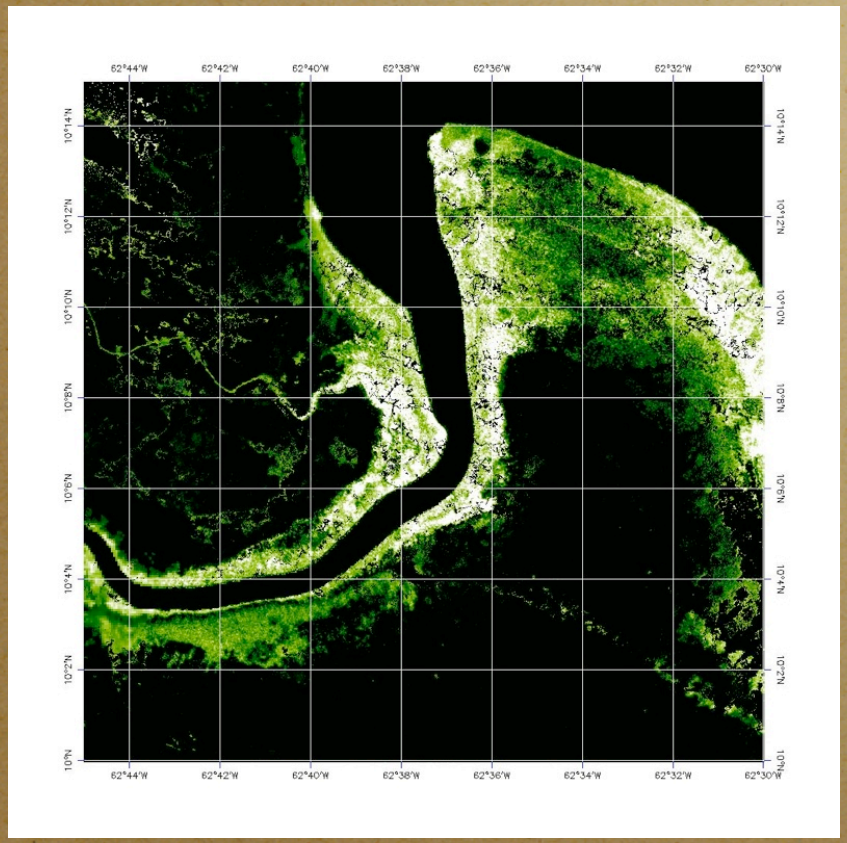
Landsat Land Cover Classification

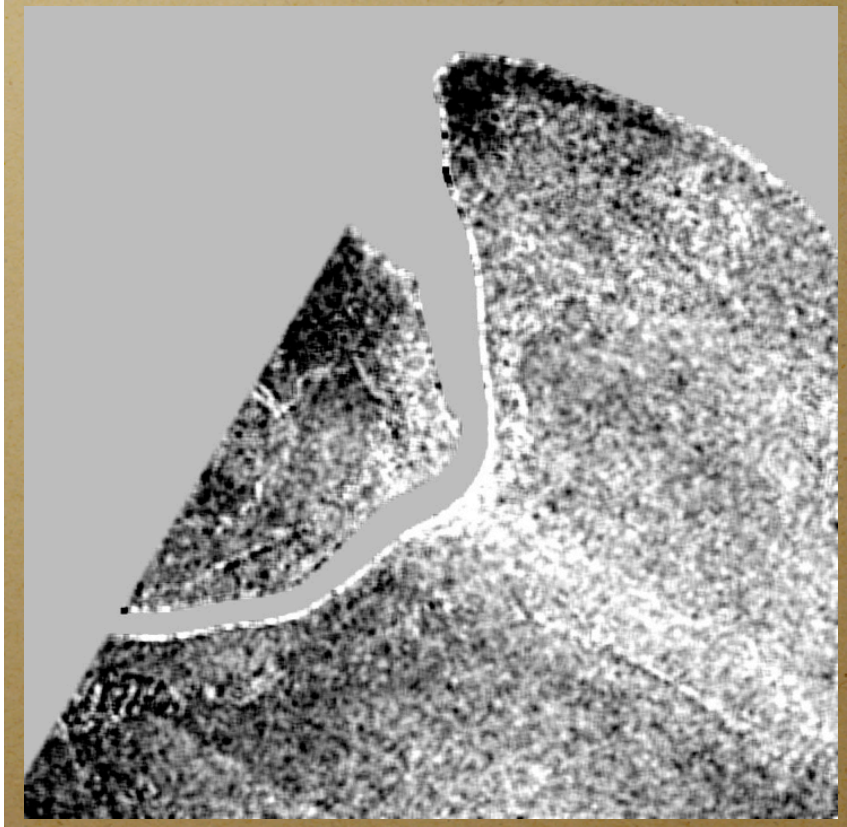


Mean Mangrove Tree Height

San Juan River Venezuela

SRTM C- and X-band

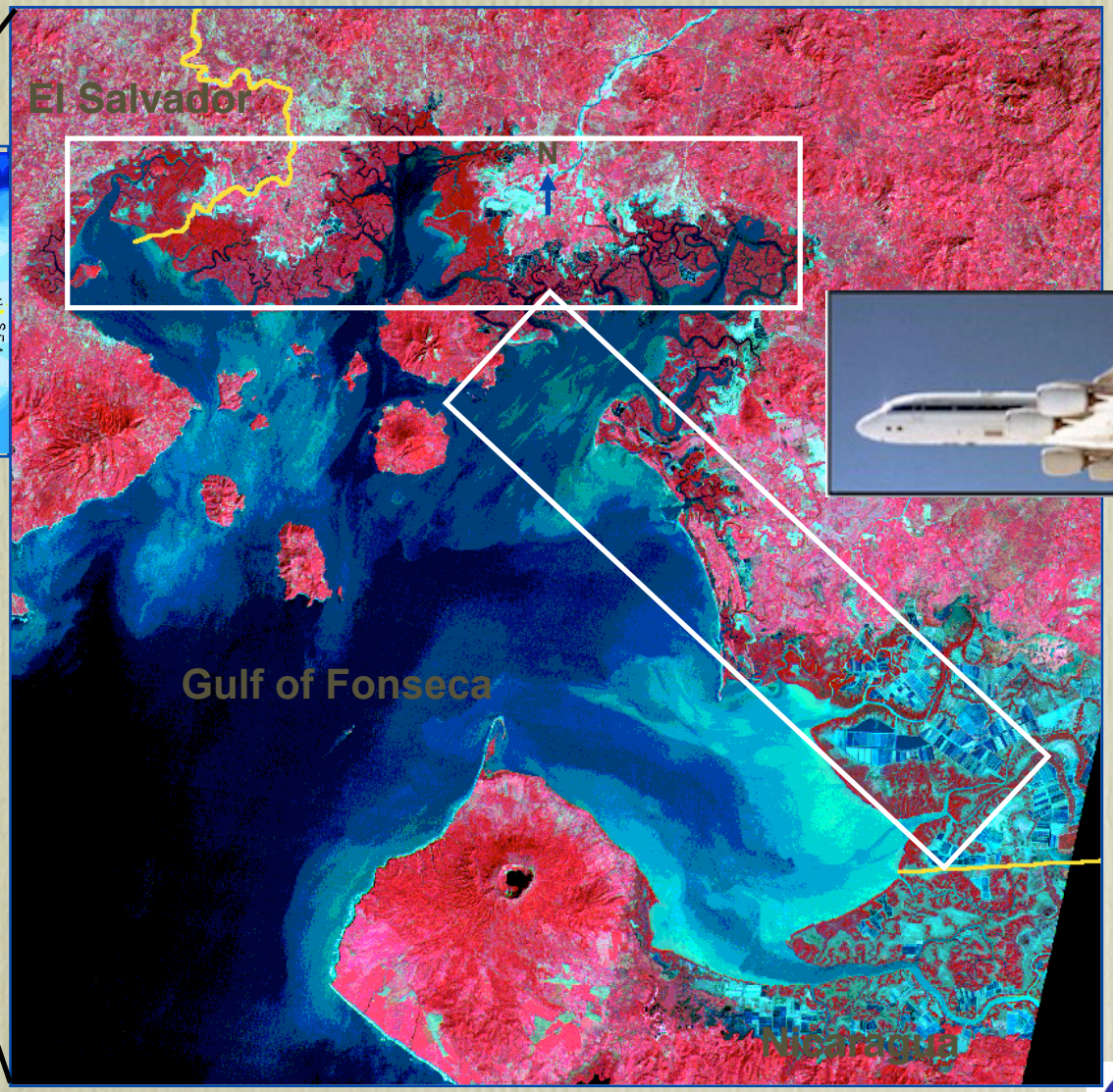




Mangrove height (0-25m)

Difference X-C from 0.6 TO 3.5m

Gulf of Fonseca, Honduras
AIRSAR Coverage



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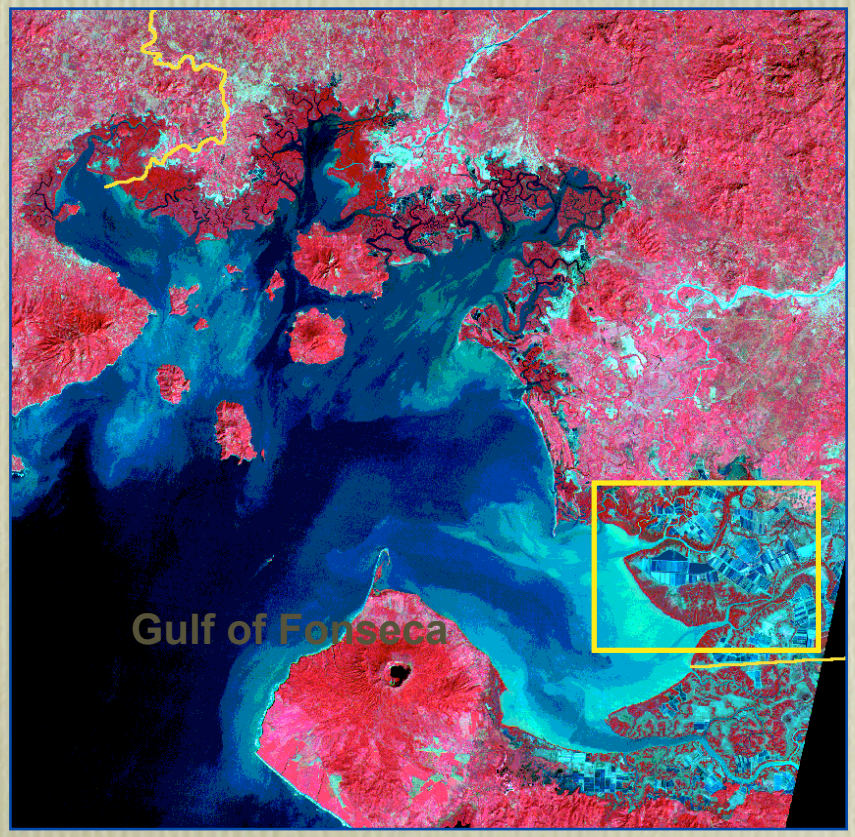
Shrimp Farming Development in Honduras

Shrimp Farming in the Southern Region of the Gulf of Fonseca



Estimated total area of shrimp ponds:

1985 = 845 ha

1999 = 15,580 ha

(V. H. Rivera-Monroy, U. Louisiana at Lafayette)

Granjas Marinas San Bernardo Shrimp Farm (7,000 ha); Largest shrimp farm in the Gulf of Fonseca.

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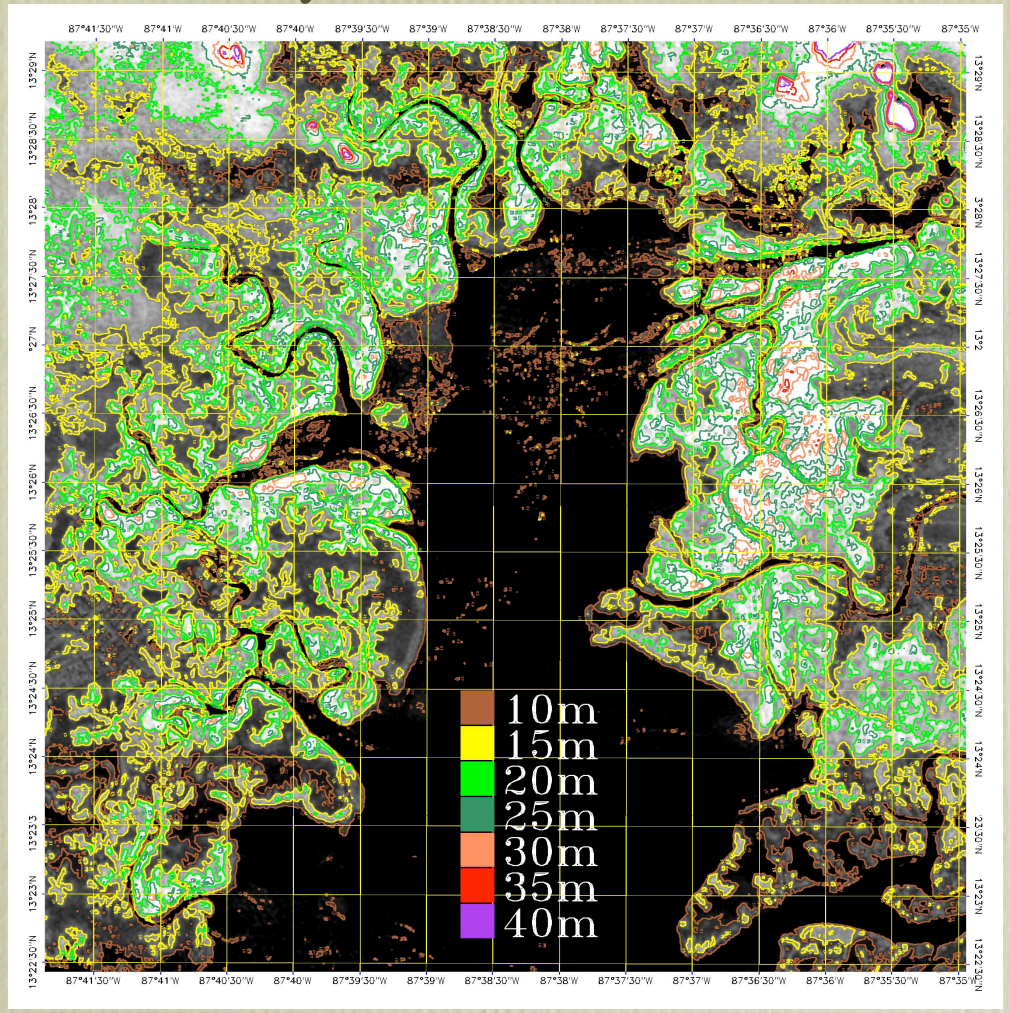
AIRSAR Vegetation Height Estimate (Chismuyo, Gulf of Fonseca)



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Conclusions

- *SRTM provides a systematic tool to map mangrove height and biomass*
- *The method is simple and works well for mangrove forests.*
- *ICEsat shows great potential to calibrate SRTM data and identify a variety of forest structures*
- *Need to apply the method to other mangrove forests around the globes*
- *Need to derive a relation between ICEsat waveform and canopy structure parameters*
- *Quantify the Impact of Hurricanes on Mangrove Forest*

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Hurricane impact

Two Category 1 hurricanes

Katrina august 25th, 2005

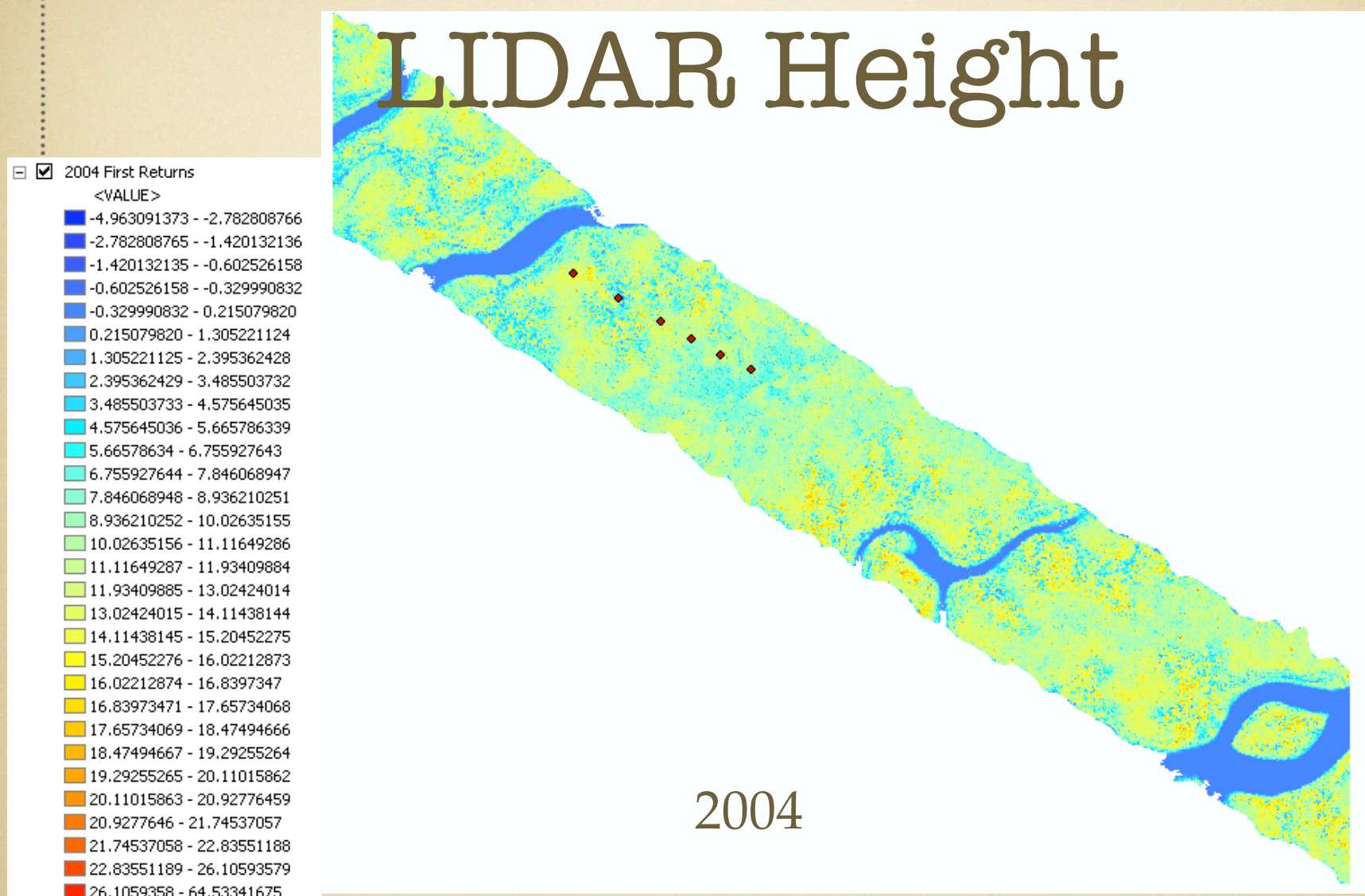
Wilma October 24th, 2005

Hurricane Damage

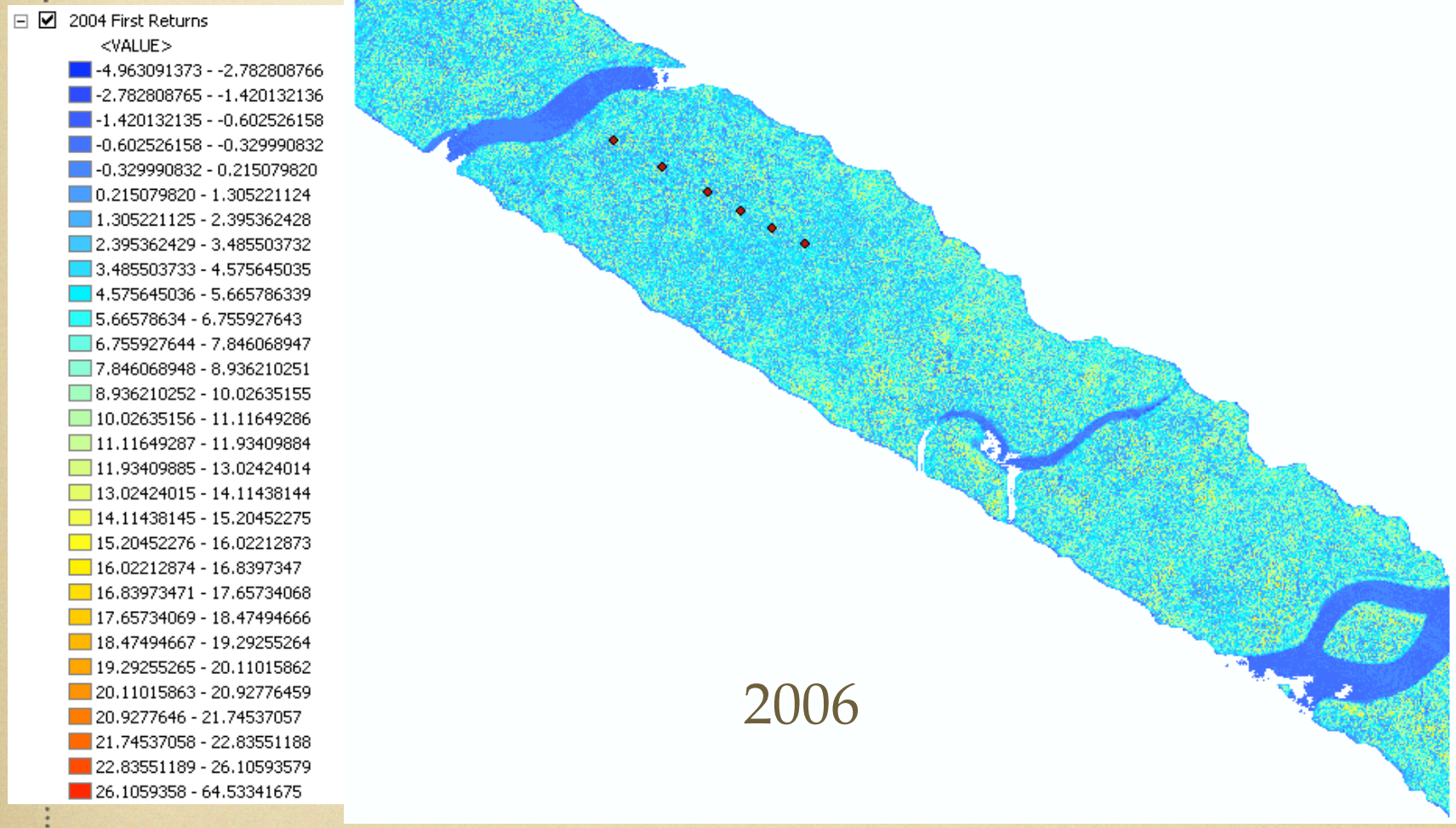
2005

2006

LIDAR Height

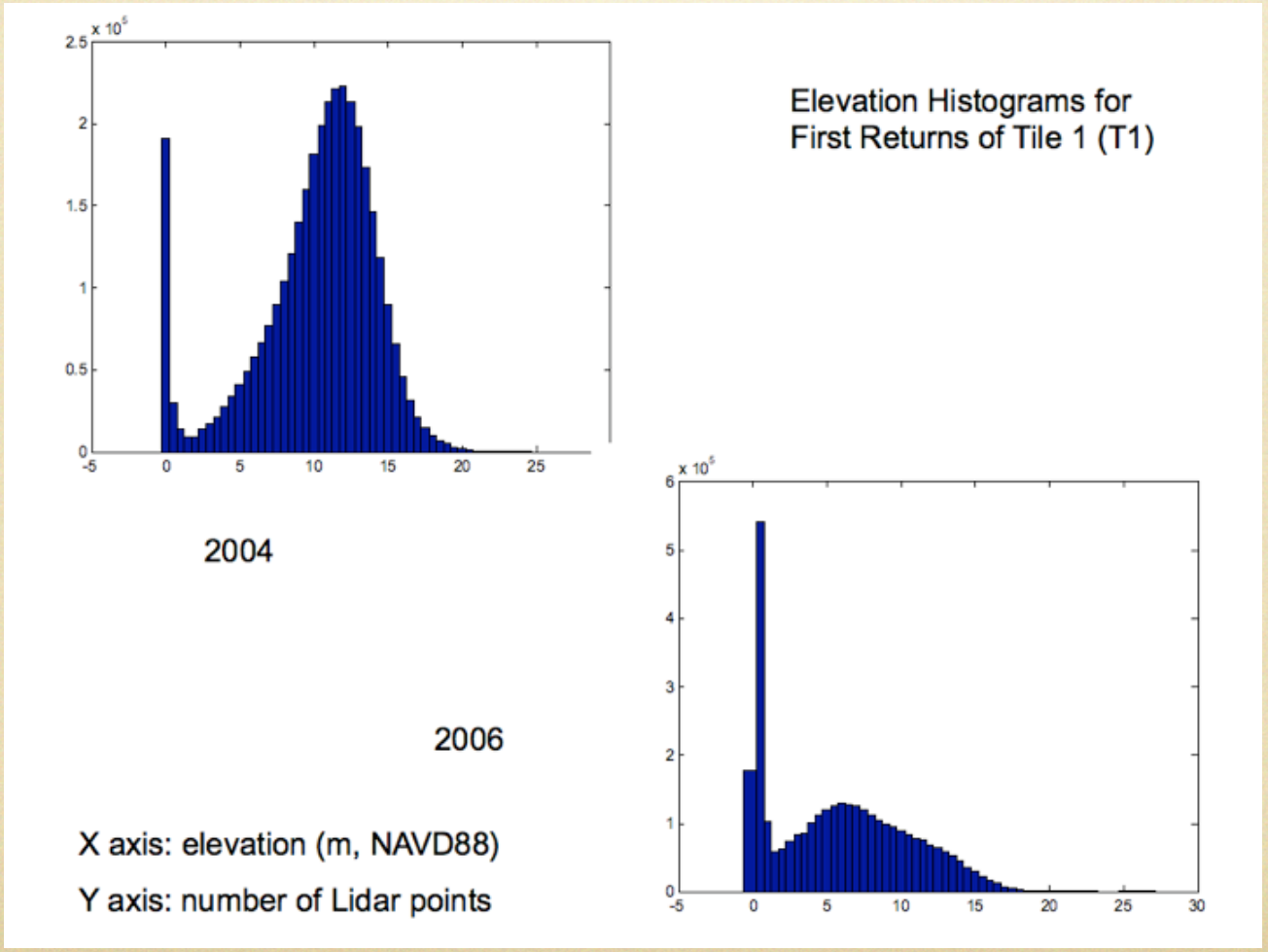


LIDAR Height

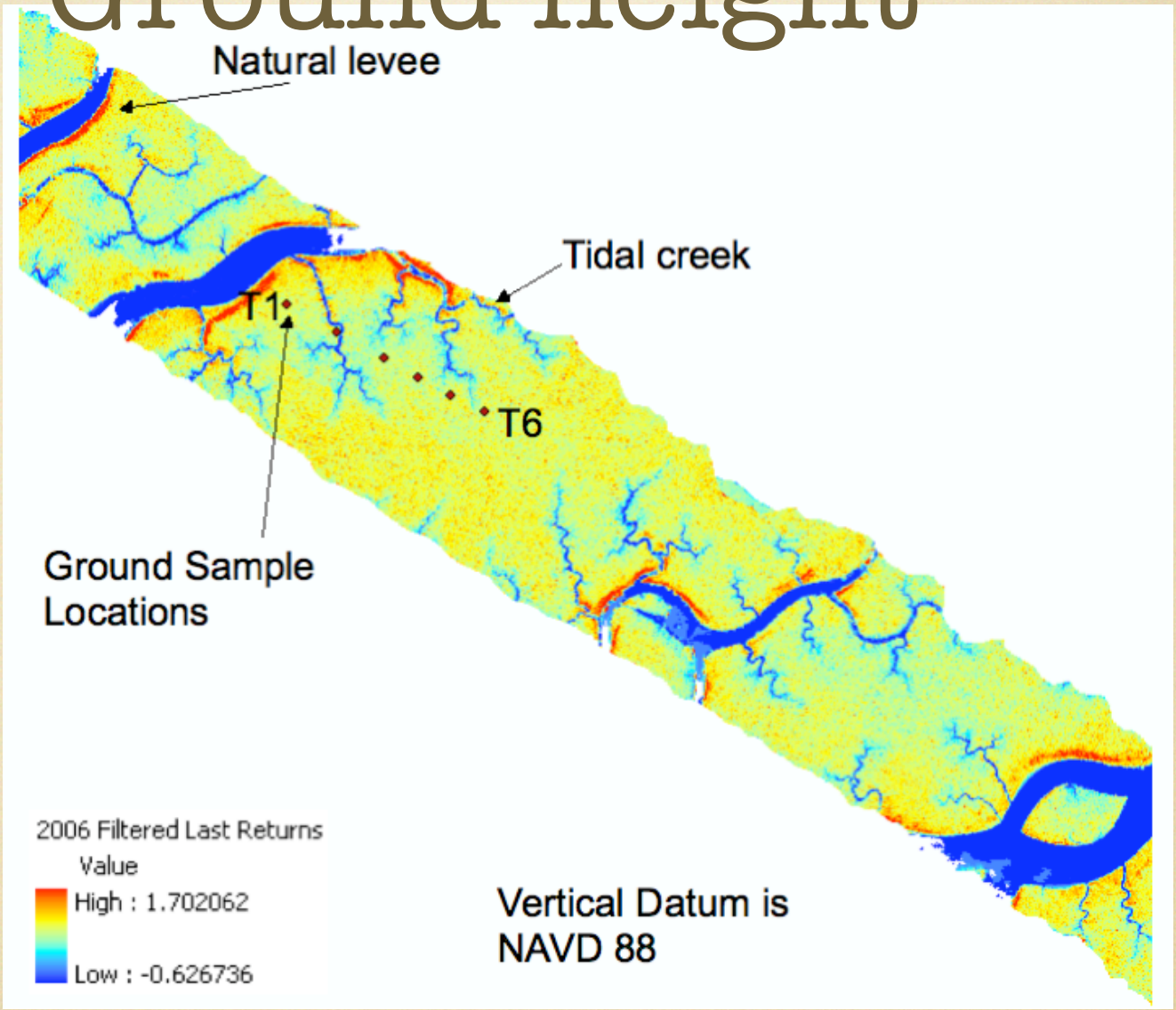


2006

Tree height histograms 2004 and 2006



Ground height



Conclusions

- What is the mean tree height?
- Can we understand structure from LIDAR data?
- How to quantify the impact of hurricanes on mangrove forests using active remote sensing?